Wildland Fuels Management: Evaluating and Planning Risks and Benefits

Final Report to the Joint Fire Science Program

#99 -1-3-16

Principal Investigators:
Anne Black, Post-doctoral Ecologist
Carol Miller, Research Fire Ecologist
Peter Landres, Research Ecologist

June 30, 2004

Aldo Leopold Wilderness Research Institute

Aldo Leopold Wilderness
Research institute
P.O. Box 8089
Missoula, MT 59807

Phone 406 542 4190
FAX 406 542 4196

Executive Summary

Wildland Fuels Management:

Evaluating and Planning Risks and Benefits

Overview

The goal of this project was to develop methods to help wildland fire managers design long term, landscape scale management plans. Although wildland fire managers have a full spectrum of strategies available for reducing fuels, they lack tools for applying these strategies at landscape scales. Furthermore, existing tools and approaches for planning fire activities focus on risk, perpetuating a cycle in which perceived risks lead to suppression, which increases risks and further fire suppression. To meet the challenge of reducing fuels and risks from fire, wildland fire managers need to use all available strategies. Using wildland fire may be the least expensive alternative, and it may be the best option for restoring the natural role of fire in wildlands. However, to use fire effectively, managers need to be able to quantify the benefits and risks of wildland fire. This information must be provided at landscape scales because managers must prioritize when and where to reduce fuels.

During this project, we designed, tested and delivered two tools that allow managers to calculate and incorporate information on risks and benefits of fire into appropriate land management planning processes.

Results

Despite a hiatus of approximately 14 months during 2001-2002 due to personnel changes, we were able to meet and exceed project objectives. We held an interagency workshop and circulated a national questionnaire of fire and fuels managers to identify information needs for wildland fire and fuels management planning. We developed, tested and will soon be delivering Users Manuals for two GIS-based models to support fire and fuels planning: BurnPro and Fire Effects Planning Framework (FEPF).Throughout the project, we worked closely with managers to ensure that we met their identified needs with tools and data available and readily useful to managers. We have also worked to ensure that technology transfer does not end with termination of this phase of the project. We have produced one General Technical Reports (Miller and Landres 2004) and are working on another (Black and Opperman in prep); have published two peer-reviewed journal articles, and are submitting an additional two; made presentations to 4 national meetings of managers, 4 regional managers meetings, and held numerous local meetings with managers, in addition to similar communication with our research peers.

The project supported planning and management at a number of sites. We sponsored development of data layers that will be used by the Bitterroot National Forest during the 2004 fire season. A data set for the Sapphire Mountain range in western Montana will be transmitted to the Beaverhead-Deerlodge, Lolo and Bitterroot National Forests to support cross-boundary planning and management in July, 2004. FEPF is being used by the Beaverhead-Deerlodge National Forest to support their Forest Plan revision and by the Sierra National Forest to support wilderness management. Its use is being considered by the Custer National Forest to support Fire Management Plan revision in 2005-2006 and by the Bitterroot Ecosystem Management Research Program to analyze effects of proposed fuels reduction actions (fall 2004-2005). Finally, analyses from this project have contributed to on-going discussions at Yosemite National Park. We developed pre- and post- burn datasets for use Yosemite National Park. These are being used to assess the role fire, particularly wildland fire use and prescribed fire, play in reducing future risk to firefighters.

Widespread use of FEPF in planning will be a function of outreach to managers, and incorporation into fire training modules and interagency fire planning. We are currently working on all of these fronts. We participated in a Technology Transfer workshop sponsored by Joint Fire Science Program (May 2004), and have been invited to participate in a workshop to determine opportunities for incorporating both BurnPro and the Fire Effects Planning Framework into the national Fire Planning and Assessment (FPA) System. We have been consulted by ESRI staff to identify options for including both models in a new ArcGIS extension to support fire planning, and have been invited by the Forest Service's Remote Sensing Application Center (RSAC) to submit a proposal in FY2005 for development of an extension of FEPF to interface with FARSITE to support incident management. We are also continuing to track and support planning efforts discussed in this report and will explore the need for and options to fund additional development and technology transfer.

Deliverables

The specific deliverables outlined here exceed our initial proposed list. Electronic and hardcopy versions of all reports and articles will be submitted to the Joint Fire Science Program office.

- General Technical Reports
    - "Exploring Information Needs for Wildland Fire and Fuels Management (Miller and Landres 2004). USDA Forest Service GTR-RMRS-127.
    - "Fire Effects Planning Framework – User's Guide" (Black and Opperman in prep. to be submitted August 2004)

- Journal articles and proceedings papers:
    - "Evaluating risks and benefits of wildland fire at landscape scales" (Miller et al. 2000) PP 78-87 In: Neuenschwander, L.F. and K.C. Ryan (tech. eds.) Joint Fire Science Conference and Workshop: proceedings; 1999 June 15-17, Boise ID. University of Idaho, Moscow, ID.
    - "The spatial context of fire: a new approach for predicting fire occurrence" (Miller 2003a) Pages 27-34 in K.E.M. Galley, R.C. Klinger, and N.G. Sugihara (eds.). Proceedings of Fire Conference 2000: The First National Congress on Fire Ecology, Prevention, and Management. Miscellaneous Publication No. 13, Tall Timbers Research Station, Tallahassee, FL.
    - "Wildland fire use: a wilderness perspective on fuel management" (Miller 2003b) Pages 379-385 in P. Omi, and L. Joyce (coords.). Fire, Fuel Treatments, and Ecological Restoration: Conference Proceedings; 2002 16-18 April; Fort Collins, CO. Proceedings RMRS-P-29. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 475 p.
    - "Barriers to fire use: getting more fire on the ground" (Black et al. in review).

    - "Fire Effects Planning Framework" (Black et al. in prep., to be submitted July 2004).

- Maps and Model output

    - All maps created for each pilot study area and accompanying documentation have been provided to the participating agencies. Due to the number of these, we are including only representative examples in this document. Additional copies or examples are available upon request.

- Models and Documentation

    - All model documentation and software is posted to our project website upon completion (www.leopold.wilderness.net/staff/projects/project_001.htm).

Challenges and Recommendations

Our goal for this project not simply to produce a model or two that conceptually addressed management needs. Should our model(s) prove useful (they did), we were interested in successfully transferring these tools to the field. We recognized that success goes beyond achieving recognition and adoption by a few research-minded managers. Success requires institutionalization of the knowledge and models. With this in mind, we developed an implementation plan that sought to integrate managers into the development stage of FEPF. Our thinking was that these 'early adopters' would be able to disperse information about the model to their peers. While this was indeed the case, several unanticipated factors pose challenges to the development and dissemination of this, and other, action-oriented research.

- We did not anticipate the time constraints facing managers. All managers we visited with concerning the FEPF were excited about its potential, but were reluctant or unable to incorporate the model into their planning process for lack of time. Despite the fact that FEPF provides an efficient and effective means to quantify progress towards management targets, time is seldom available for such purposes. We were able to facilitate the use of FEPF by one manager (Opperman, a Forest Service fire ecologist) by providing her with funding. Other managers (NPS and USFS) expressed interest in using the model for revision and development of Fire Management Plans, and even committed to doing so, but were unable to devote sufficient time to complete analysis by the end of this project. We take their continued interest and commitment as a sign that they feel the framework *does* have merit and as support for our supposition about time.

- While our vision was to use FEPF as a tool to *develop* alternatives for long-range planning, (which occurs early in the planning process) the forest planners we worked with view the tool as useful for *effects analysis* (which occurs much later in the process). The consequence of this is that four of our planned pilot study locations (Beaverhead-Deerlodge National Forest, R01 Western Montana Planning Zone, Bitterroot Ecosystem Management Research Program, and the Custer National Forest) have not yet reached the effects analysis stage; thus, we have no concrete results for these efforts as of the formal end of this project (June 2004). All participants remain interested in using FEPF at the effects analysis stage, which will occur over the next 2-3 years.

- Researchers must often choose between high-tech and high-transfer; that is to focus on development of new scientific information, or development of a science delivery program. Because our initial assessment of needs from managers identified an immediate need for information, we chose the latter path.

We recommend that as the JFSP Governing Board proceeds to encourage strong Technology Transfer (TT) linkages in future research, they explicitly consider the various stages of TT: dialog, implementation, integration, and institutionalization. It may be appropriate to provide separate funding to support the third and fourth stages of TT. The rationale behind this is two-fold: 1) the managers attracted to new research projects do not represent the entire group of managers successful research must reach; and 2) tasks associated with integration and institutionalization call upon different skills and timelines, and may provide different rewards than many research-grade scientists are interested in or willing to pursue. As an example, the latter two phases of TT are unlikely to produce the type of publications for which research-grade scientists are evaluated.

Table of Contents

List of Figures

Chapter 1 Introduction

Purpose and Need

The Federal Wildland Fire Policy Report of 1995 declares that "wildland fire, as a critical natural process, must be reintroduced into ecosystems". Although the lack of wildland fire, particularly in wilderness, directly conflicts with federal law and policy, suppression remains the dominant strategy in wilderness fire policy across all agencies and the number of acres burned each year is far short of that needed to restore natural fire regimes (Parsons and Landres 1998). Each decision to suppress wildland fire contributes to a reinforcing feedback cycle in which risk to property and ecosystems escalates, fuels continue to accumulate and the tendency to suppress fire grows (Saveland 1998, Miller et al. 2000).

Wildland fire managers can utilize both naturally ignited wildland fires and management ignited prescribed fires as well as, in non-wilderness situations, thinning and other mechanical methods to reduce fuels and restore fire. There are a variety of tools and methods available to predict fire behavior and first order fire effects (e.g., Andrews 1986, Finney 1994, Reinhart et al. 1997). Yet, even with these tools, managers are unable to effectively utilize fire to meet policies of fuels reduction and ecological health for at least three reasons:

1. *Inadequate tools for landscape planning.* Most decision support tools for fire planning and decision-making focus on the occurrence or movement of fire without considering fire effects and the values that may be affected by fire (Finney 1994, Perkins 1994, Wiitala and Carlton 1994, Lasko and Tine 1995, Sapsis et al. 1996, Burgan et al. 1997). Approaches that do explicitly treat fire effects and values at risk generally have ignored the potential benefits from fire (Close and Wakimoto 1995, Burton et al. 1998,). This leaves no systematic process for identifying, quantifying or articulating benefits, services and consequences; for identifying how monetary costs and risks to commodities can be compared to non-monetary benefits and risks; or for integrating this information into the various

planning and implementation procedures. Lack of information on the benefits of fire during long-range planning, at the "go/no-go" decision, and during a fire event, predisposes managers towards suppression (Miller and Landres 2004). Moreover, most of these tools are stand-based, whereas our need for fire information is at the landscape-level.

2. *Competing and mis-matched management objectives.* Wildland fires are suppressed when the goals of protecting concrete and immediate social values (such as threats to private property) override those of vague and long-term social values (such as restoring the natural role of fire). Each decision to suppress wildland fire reinforces a feedback cycle where fuels continue to accumulate, risk escalates, and the tendency to suppress fire grows.

3. *Lack of information on fire benefits*. Although wildland fire managers need to balance the benefits of fire use with the risk it carries, existing tools and approaches focus primarily on the negative consequences of fire. Without information on the benefits of fire, the justification for using wildland fire as a fuels management strategy is limited (Miller and Landres 2004). Managers have little information with which to engage the public in a discussion of the appropriate role for fire, and little evidence to support their decisions. Given predominantly risk-focused information, rational decision-makers (both public and managerial) will base their decisions on risk, thus perpetuating the cycle of risk and suppression.

Project Description

We proposed to develop methods that allow managers to incorporate information on the risks and benefits of wildland fuels management into landscape sale planning to help design landscape scale fire and fuels management plans, help managers effectively use the entire suite of fuel reduction strategies available to them, and help break the cycle of risk and suppression that currently limits the effectiveness of fire management programs nationwide.

To accomplish this, we envisioned convening a workshop of fire managers and fuels specialists representing different agencies and geographic areas to identify common information needs. These needs were to guide model development. The proposed GIS model would be grid-based with a resolution of 30 m, and consider fire occurrence, fire severity and values. Prototype validation was to occur in 3 geographic areas.

Goals and Objectives

The proposed model was intended to be used to identify areas on the landscape of high priority for fuels treatments and to evaluate the effectiveness of alternative fuel reduction strategies for reducing overall fire risk. The following objectives helped ensure broad application of the model:

- Design the model to be dependent on generally available data;
- Develop the model using at least three pilot study sites representing different fuel types and geographic areas;
- Incorporate input and feedback from managers in model development; and
- Enable use of the model by multiple agencies by ensuring that model output is compatible with multiple database structures and computer platforms.

Chapter 2 Analysis of the Planning Context

Framing the Issue

Fire suppression directly compromises natural fire regimes, leading to fuel accumulation that increases the risk of fire to ecosystem health and human values, which in turn increases the perceived need for suppressing fires. Both the Federal Wildland Fire Policy (FWFP) and the National Fire Plan (NFP) were developed and implemented during the last decade to address this reinforcing feedback loop. Yet, despite the best intentions, efforts under these policies have met with mixed success.

Our charge under this project was to develop tools that can assist federal land managers meet their fuels reduction goals, particularly goals related to restoring natural fire regimes to wilderness areas through successful Wildland Fire Use (WFU) programs. To do so effectively, we needed to understand the full context of the planning environment within which managers work. How are plans procedurally and substantively linked together – national to local as well as across disciplinary lines within each management unit? Who is involved at each stage and what data and planning tools are available to them? In essence: what are the barriers to fire use? And from this: What opportunities exist to overcome these barriers and enable achievement of national fire policy goals?

Methods

To identify barriers and potential solutions to increasing fire use, we first examined fire management within the larger context of federal fire and land management directives. We reviewed the scientific literature, US public policy, and federal agency planning documents, including national policy directives, broad-scale, multi-year Resource or Land Management Plans, and annual tactical and strategic Fire Management Plans. The review was also informed by results from a nationwide, multi-agency questionnaire of fire managers, our multi-agency workshop to identify information needs (Miller and Landres 2004), and a series of interviews with managers conducted in 2001 concerning how they access and use science (Kearns and Wright 2002).

To refine our understanding of potential barriers and relate these to specific on-the-ground fire management, we held a series of one-on-one and group meetings with fire and land managers – fire management officers, fire and fuels planners, management plan revision teams, line officers, ecologists, rangeland and wildlife biologists – from local to regional to national levels. We met predominantly with staff in the Department of Agriculture's Forest Service, but also met with staff of state wildlife and fire-fighting organizations, the US Department of the Interior's Bureau of Land Management, Fish and Wildlife Service, and National Park Service, and a private, non-profit organization – The Nature Conservancy. We sought the full range of affected agencies, management levels and positions using a "snowball" technique (Schutt 1999) beginning with multiple entry points to ensure capture of the most important barriers to fire use.

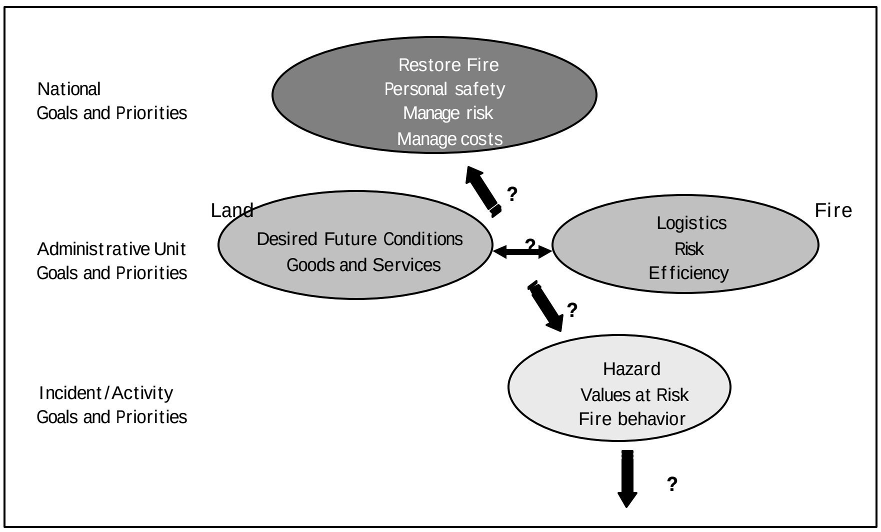
Barriers to Fire Use

Multiple barriers operate across and between organizations and organizational levels -on the ground, in the planning processes, and in agency policy. Of particular concern, and within the capacity of managers to address, are: mis-matched planning units, nearly exclusive focus on costs and risks, and a nearly exclusive reward for risk-averse decisions (Black et al. in review).

Mis-matched planning units. We found a lack of functionally integrated planning processes and terminology. Despite policy directives charging agencies with responsibility for "ensur[ing] that wildland fire management is fully integrated into land management planning" (NIFC 1998), functional integration rarely exists. A key reason seems to be a lack of common terms and units of analysis across and between planning levels. Each of the various levels of fire and land management (national, regional, and local administrative units, and incident management teams) has its own set of goals and priorities (**Figure 1**). Goals and priorities are articulated and measured differently, with no explicit or consistent method of integrating results for meaningful integration, or measurement of progress or success. National goals speak broadly of restoring fire, managing risks and costs. Land managers in the administrative areas (Resource Areas, National Forests, Wildlife Refuges, etc.) focus on the decadal production or maintenance of goods and services to achieve these long-range goals. They focus on vegetative conditions, potential for commercial biomass removal, and maintenance of biodiversity in time scales rarely dipping below annual time steps. Meanwhile, fire managers at the same administrative unit level grapple with tactics and logistics across management boundaries, calculate risk, and outline broad fire strategies on an annual basis. At the incident level, fire managers consider fire behavior, determine hazards, identify values at risk, and decide fire-line tactics over hours, days, or weeks.

Focus on costs and risks. We identified three decision-spaces in which lack of information on the benefits of fire predispose managers towards suppression: long-range planning, "go/no-go" decision, and during a wildland fire incident.

Figure 1. The Problem – uncoordinated units of analysis make integration and achievement of national goals difficult.



<u>The long-range planning decision-space</u> concerns identification of WFU zones in broad-scale planning documents. Information on benefits does not generally appear to be considered in current plan revisions. Without this information, the designation of WFU zones during long-range planning processes may not occur, and the legal stage for the restoration of fire using natural ignitions may never be set, thus eliminating the opportunity to utilize natural fire to achieve policy objectives.

<u>The "go/ no go" decision</u> - whether to manage a natural ignition as WFU or to suppress – must be made within 2 hours of first report. Although an underlying presumption in policy appears to be that all fire is good and should be managed as a WFU unless risks are too great (Bunnell and Zimmerman 1998), explicit discussion of benefits is not required to make the "go/no go" decision. This means that documentation of a significant aspect of a 'go' decision – benefits - is most often missing. Local line officers may be able to bring personal experience into their decision process; however, this information is generally undocumented and undocumentable. Local experience is therefore lost whenever the national preparedness level escalates the authority required for WFU decisions to non-local line officers (e.g., regional or federal levels). Moreover, the lack of documentation leaves decision-makers vulnerable to and increases the likelihood of a personnel crisis should unforeseen circumstances result in disaster following a 'go' decision (see next section).

<u>Incident support</u> Under present policy, incident managers are discouraged from assessing net benefits and costs of a *suppression* event. Consideration is only given to potential resource losses, and of these only of losses of commodity values, such as timber and forage for livestock. Furthermore, the losses are considered only over very short time frames (e.g., 2 years post-fire for loss of forage) (USDA 2000). There is no valuation of the thinning or other forest management activity provided by a fire, the post-fire forage production created, the critical wildlife habitat provided, or future catastrophic fire risk reduced. Nor is there assessment of the risk that continued suppression has on ecosystem health. Given the fast-paced, shortened timeframe that characterizes incident management, information on benefits and risks will not be generated during an incident; to be useful, it must be available prior to the onset of the fire season.

Reward for risk-aversion. Lack of institutional support for risk-takers leaves few decision-makers comfortable with any fire management decision other than suppression. The decision to suppress is not held to the same level of scrutiny, regardless of the short- or long-term outcome. Nor does the level of scrutiny given to WFU and prescribed fires that have 'escaped' match that of suppression event. This makes the decision to defer ignition of a prescribed burn or to suppress a natural ignition the safest one for the individual manager, though that decision is likely to increase future fire risk.

Opportunities for Dismantling Barriers

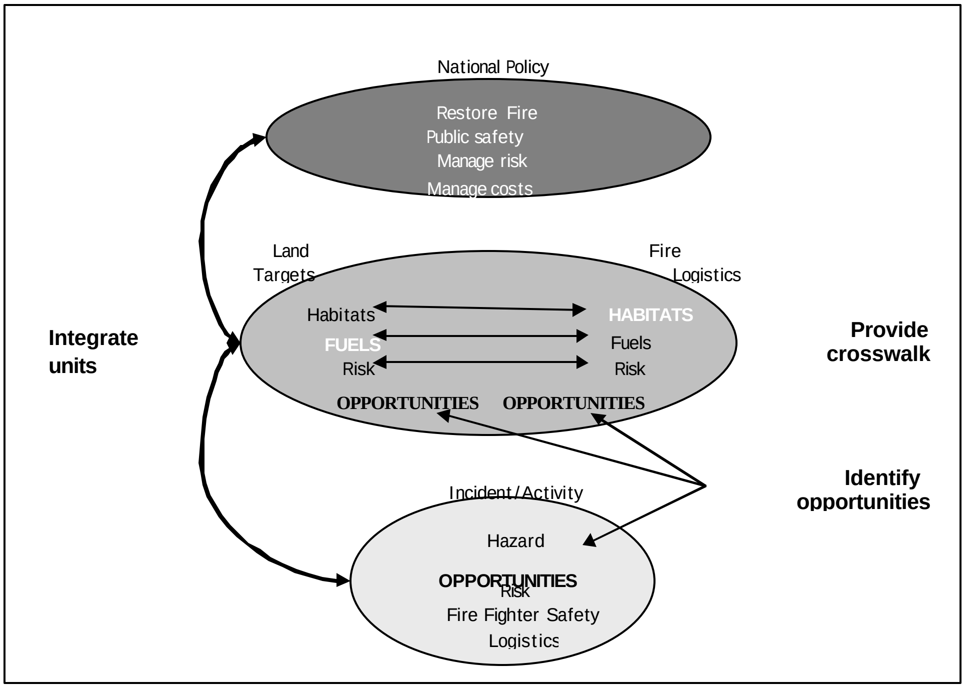
> The importance of this kind of work has been driven home to me this fall. We converted 2 of our fire use fires to suppression due to smoke concerns and then spent over 5 million dollars putting them out. (Kara Paintner, Fire Ecologist for Yosemite National Park).

Based on our assessment of planning barriers, we identified a number of actions federal agencies can take immediately and within the current administrative structure to help mitigate the tendency towards suppression:

- Develop *a crosswalk of terminology and analysis units.* Crosswalks of language and units of analysis are needed to allow translation and mutual understanding of tactics, targets, and goals across planning scales and between fire and resource management teams (**Figure 2**). Clearly articulate common units of analysis and measurement in terms relevant for both fire and land managers. Specify measurement units that allow fire and land managers to easily identify common priority areas and provide meaningful measures of progress (e.g., linking fuel loads, stand structure, and wildlife habitat).

- *Integrate across all planning units and time horizons.* Use information on the ecological and social benefits of fire to identify: additional areas for Wildland Fire Use consideration (the long-range planning phase); opportunities and priorities for fire use within these areas (the Fire Management Plan and Prescribed Burn Plan phases); and least cost/greatest benefit options for incident management (WFSA/WFIP planning phases). Link the broad, long-term targets to annual activity targets (e.g., prescribed fire acres) and to incident management (WFU and suppression) criteria and goals to ensure on-the-ground activities support broader goals at minimum cost.

Figure 2. The Solution - reconciled terminology and use of common units provides the basis for functional integration.



- *Identify opportunities and document benefits.* Develop processes and protocols for identifying opportunities to use fire to achieve respective and mutual goals of fire and resource managers and for integrating this information in a timely and useful manner into planning and incident management. Use this documentation as part of a post-season assessment, as a basis for allocating incentives and dismantling dis-incentives, and as a pre-assessment of next-season's priorities. If information on the benefits of fire is generated prior to the fire season, it is available for the go/no-go decision-window.

Our assessment of planning barriers also drove home to us both the immediate need for this information and the time constraints under which field managers operate. New programs or tools that require additional analysis, training or new data are unlikely to be used by managers. However, new information will be used if researchers generate and provide the completed product. Due to our project timeline, we identified a number of features to incorporate into our project:

- *Use existing data, computer tools and skills*. As much as possible incorporate existing knowledge and tools into new products and procedures.

- *Minimize additional analyses.* As much as possible base new analyses on work already being completed for any given planning effort. Testing of the initial products in the field needs to be facilitated (paid for if not conducted) by researchers.

- *Facilitate use of any new procedures.* Concentrate on minimizing training requirements and seek to shorten the learning curve for any new procedures. Develop user's guides and fact sheets to accelerate adoption of new analyses. Demonstrate the utility of the process or tool by using real planning situations and tools. Begin the technology transfer process as early as possible and take advantage of any and all opportunities to explain and demonstrate the process.

Formatted: Bullets and Numbering

Chapter 3 Planning tools

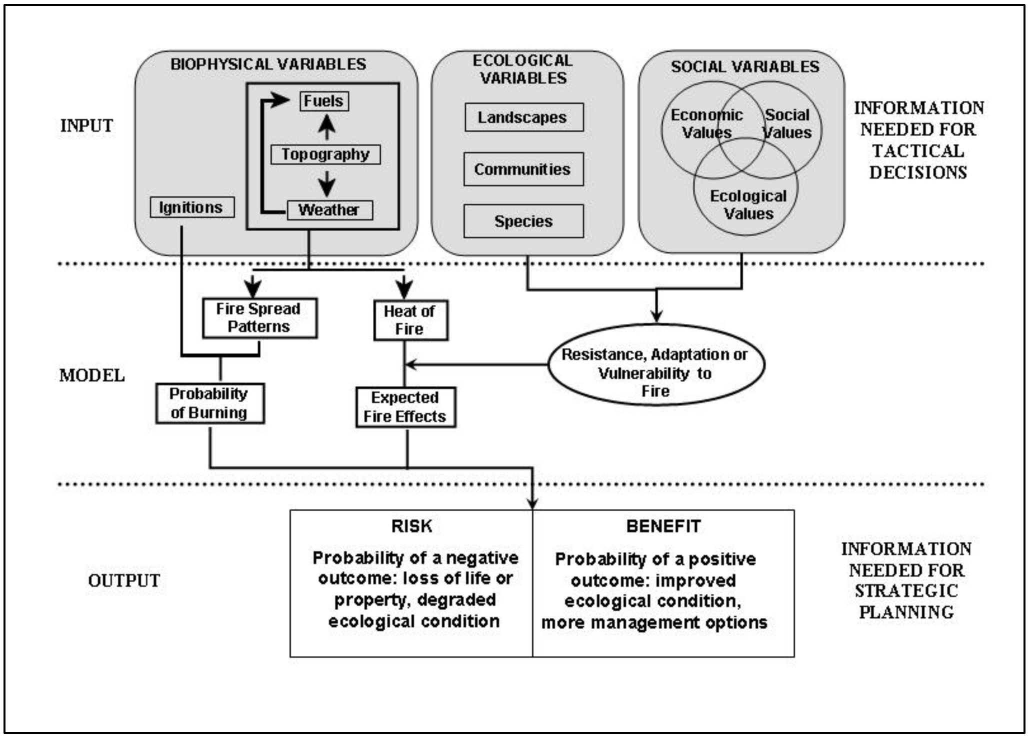
Identifying Fire's Benefits and Risks

We refined the conceptual model outlined in our proposal and described by Miller and others (2000) to integrate social and biophysical processes involved in fire and fire planning (**Figure 3**). Fire is a physical process described by quantitative measures (such as heat per unit area or energy release component) or by the qualitative assessment of fire effects (predominantly, though not exclusively, described by effects on above-ground biomass, such as crown fire or stand replacing fire). Fire in and of itself is neither good nor bad, desirable nor undesirable; it is the human social system that makes that determination. Thus, fire is also described as posing risk or benefit. Here, we use risk to mean the probability of loss due to fire (Rowe 1975, Suter 1993). Risk can be quantified in terms of probability of fire-damage to resources or property. Fire benefits can be defined as 'negative risks' (Rowe 1975) or as the probability of a gain due to fire. Benefits can be quantified in terms of the probability of gain, improvement in or reduction of threats to resources or property.

The current negative feedback cycle of risk and suppression operates at the interface of the social and biophysical systems by decreasing the resiliency of ecological systems to fire. It also recognizes that adjustments within the social system such as adoption of Firewise housing strategies (www.firewise.org) can decrease society's vulnerability to fire. Likewise, greater use of fire can increase ecological resiliency, such as through restoration of fire resistant stand conditions.

We operationalized this conceptual framework with two GIS-based, landscape-scale planning tools: BurnPro and the Fire Effects Planning Framework. BurnPro estimates annual probability of burning and can be used to help prioritize WFU opportunities as well as fuel treatment activities. FEPF links existing tools and information together and guides managers in the development of information on the risks and benefits of wildland fuels management.

Figure 3. Revised conceptual model.



BurnPro

BurnPro is a GIS model that estimates the annual probability of burning for every cell on a raster landscape (Miller, 2003a, Davis and Miller 2003). BurnPro uses topography, historic weather, fuel model data, and historic ignition locations to estimate the likelihood of burning given the speed and direction a fire might spread from any ignition point. The approach in BurnPro follows logic similar to that used in the fire management application tool RERAP (Rare Event Risk Assessment Program), which estimates the likelihood that a fire will threaten a designated geographic location or point of concern before a fire ending event (i.e. precipitation) will occur (FRAMES 2003). Whereas RERAP is used to perform a nonspatial analysis for a single fire incident, BurnPro translates this concept to a spatially explicit landscape for multiple possible fire incidents occurring over time periods ranging from years to decades. The probability that fire will travel through space and time from an ignition source to any point on the landscape depends upon 1) the time required for fire to travel the distance from the ignition to the target, 2) the frequency distribution of fire-stopping weather events (e.g. heavy rains) within the fire season and 3) the time remaining inthe fire season.

To compute this probability, several spatial data layers are derived: classes of ignition density for each month during the fire season, the time required for fire to spread from an ignition to any point on the landscape under different classes of fire weather, and the length of the fire season. Historical fire weather data are used to derive fire spread times under different percentile fire weather conditions and to determine the frequency of fire-stopping precipitation events during the fire season. Several existing modeling tools are used to generate the intermediate information needed to implement this approach, including Fire Family Plus (Main et al. 1990) and FlamMap (M. Finney, U.S. Forest Service Fire Sciences Lab, unpublished model). A simulation model of soil moisture is used to approximate the length of the fire season as it varies across elevation (Urban et al. 2000). AMLs (Advanced Macro Language) is used in ARC/INFO (ESRI 1998) to manipulate and derive these spatial data.

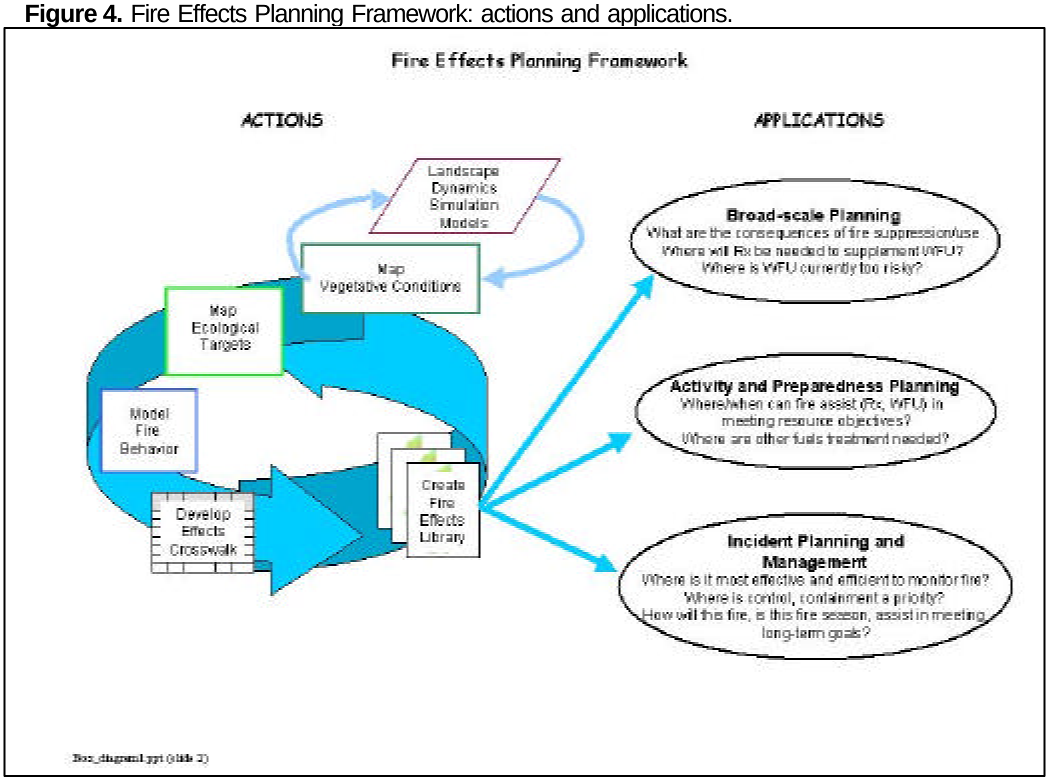
From these intermediate data layers and manipulations, probability of burning is calculated for each ignition density class, each month, and each weather class. The resulting estimate of annual probability of burning is computed as a weighted average of these individual probability maps. The average annual probability of burning can be used in combination with fire effects analyses produced with FEPF to help managers delineate zones where WFU may be a feasible fire management strategy and where fuel treatment activities are a priority.

Fire Effects Planning Framework

Overview

FEPF allows managers to systematically determine (map and quantify) where and under what conditions fire is likely to create benefits or pose threats to important ecological conditions and management targets. Fire risk and benefit are estimated as functions of the probability of burning, the expected fire severity, and target conditions. FEPF is not a stand-alone tool; it is a 'meta-model' or framework that sequentially links state-of-the-art, publicly available analysis tools, data and knowledge to generate information for a variety of planning scales from long-range to site-specific (Black and Opperman, in prep). The key to implementation is development and use of map libraries in the off-season to inform strategic planning, and provision of data in ditigal and/or hard copy form for tactical planning during the fire season.

Figure 4. Fire Effects Planning Framework: actions and applications.



The basic process is straight-forward (**Figure 4**):

1. Map existing conditions of each planning target (fish and wildlife, vegetative condition, fuels, fire fighter safety, etc);
2. Identify how various fire behaviors (e.g., surface vs. crown fire) are likely to affect targeted resources (causing a move towards or away from desired condition) and capture this in database 'crosswalks';
3. Use these crosswalks to build GIS map libraries that display expected effects of fire on social and ecological values.

This can be embellished in any number of ways, for instance by linking to a landscape dynamic simulation model to predict future fire behavior and effects.

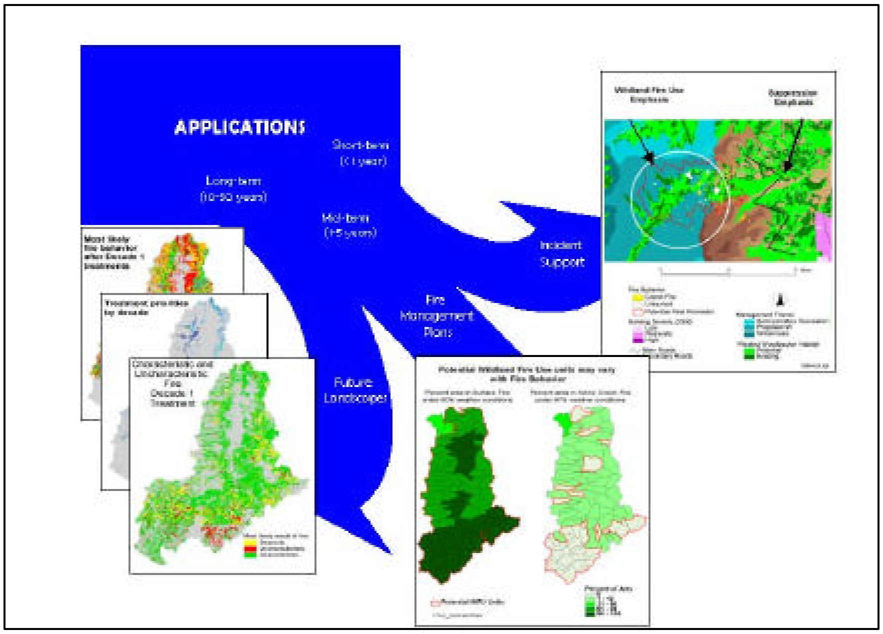
The conceptual model is operationalized by linking existing computer tools together sequentially to generate measures of the biophysical process of fire and fire effects that can be linked to social goals articulated in long-range planning documents and calculating 'risk' and 'benefit' as functions of fire effects on social targets.

FEPF capitalizes on measures of the fire process used by fire managers for strategic and tactical planning such as flame length, rate of spread, fireline intensity. Because fire varies considerably over both time and space, FEPF computes fire behavior under a gamut of typical fire weather conditions.

FEPF then prompts users to identify how these fire behaviors are likely to affect resources of key management interest such as future vegetation condition, habitats, fuel loads. Determination of 'risk' and 'benefit' is made by linking effects on resources back to management targets. 'Benefits' accrue where fire will assist in meeting management targets and objectives. Conversely, 'risks' occur when fire will inhibit achievement of management targets and objectives.

The resulting map libraries characterize benefits and risks in terms meaningful to resource managers under a variety of conditions meaningful to fire managers - from effects of burning under normal fire weather conditions to effects under extreme conditions. These maps can then be used to identify where fire is likely to provide benefits or pose risks to planning targets; identify priorities and feasibility of wildland fire use (WFU), prescribed fire (Rx), mechanical treatment or suppression; quantify the cumulative effect of a fire season on long-range planning targets; or analyze alternative management strategies for long-range planning (**Figure 5**).

Figure 5. Application of FEPF output.



FEPF's products - map libraries of fire behavior, risk and benefit - can be used to:

- develop landscape scale plans that identify where fire is likely to provide benefits

or pose risks to planning targets and maximize the benefits of wildland fire (such as future reduction in fire behavior or improved wildlife habitat) while minimizing the risk (to life, property, fragile ecosystems);

- strategically prioritize areas for fuels treatments and identify feasibility of wildland fire use (WFU), prescribed fire (Rx), mechanical treatment or suppression;
- quantify the cumulative effect of a fire season on long-range planning targets;
- analyze alternative management strategies for long-range planning; and
- provide spatial information for fire event management.

Methods and Study Sites

We designed the Fire Effects Planning Framework to take advantage of data, computer models and knowledge generally available to federal land managers. To identify available datasets and tools, we sought management input (fire, fuels, and resource staff, planners and line officers) from all federal land management agencies using a variety of sampling techniques. We initially conducted a national questionnaire and held a workshop to gain a more comprehensive understanding of information needs faced by wildland fire managers, across agencies and within both fire and fuels staff positions (Miller and Landres 2004). We also drew on the findings of a case study investigating the barriers to use of science by wilderness fire managers (Kearns, unpublished federal report 2002). This understanding – of information needs, data and tools available - informed the development of a process to sequentially link the identified programs to address and meet the identified information needs.

The general concept of FEPF was vetted at local federal land management planning team meetings, regional fire staff meetings, regional research colloquia, national and international professional meetings and as well as with some of the original workshop participants and model developers. These presentations were both selective as well as opportunistic.

The FEPF concept was then implemented in an initial development phase. We used data from the Beaverhead-Deerlodge and Bitterroot National Forests (MT) and Yosemite National Park (CA) to test potential models, develop the analysis process and identify possible output information. Results from this first draft of FEPF were taken back to the appropriate field units (both management and scientific) through another series of meetings, and to professional scientific societies through conferences and annual meetings.

Finally, the revised draft framework was provided to managers to use and test. To ensure that at least some feedback returned to us, we contracted with the Bitterroot National Forest to develop final datasets using FEPF. This stage sought to refine initial analyses, train field staff in the framework, and obtain input from users/managers on necessary refinements of both the process and communication devices (fact sheets, website, and guidebook).

Operationalizing the Fire Effects Planning Framework

As described above, FEPF is more of an analysis process, or framework, than it is a stand-alone model. This is in large part due to the state of our knowledge. Ideally, FEPF would rest upon a suite of models that provide quantitative measures of the contagious processes involved in vegetative succession and disturbance (species establishment and growth, fire, disease, fuels, and management) across the entire U.S. Unfortunately, although there are a rich variety of models currently available, none can 'do it all'. In general for any given location, one must choose between stand-based models (generally deterministic and quantitative) and landscape-based models (generally stochastic and qualitative). Few landscape models are parameterized for regional or national application at this time; not all management units have the requisite data for stand-based models.

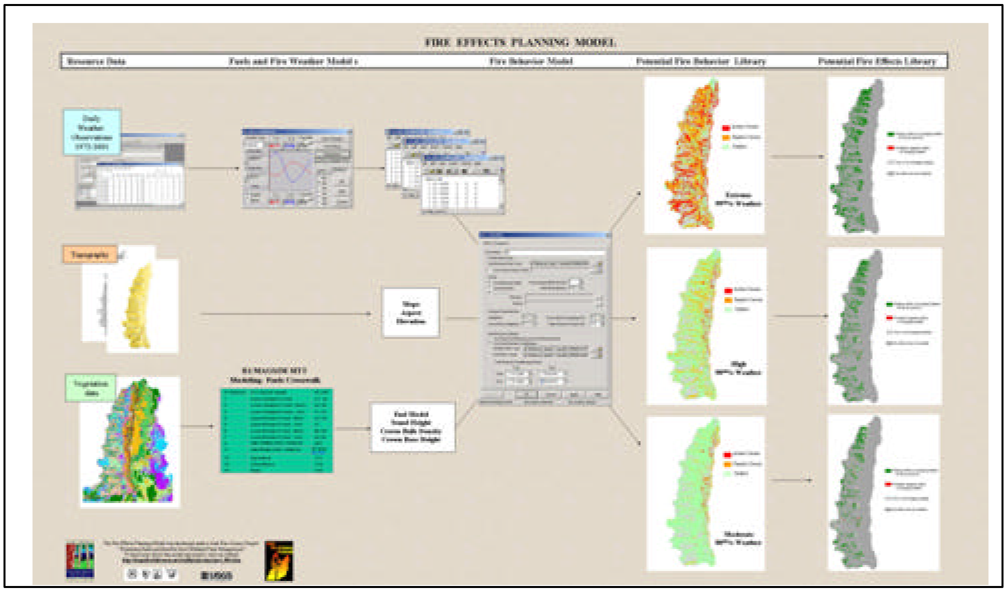
To meet our objectives, we designed a system to which users can apply their own data, expertise and preferred models. To develop and test FEPF, we joined several on-going planning efforts. For each, we used the data and tools currently available to the resource staff and managers and sought to provide output relevant for that planning stage. To ensure operability and to facilitate use, we generated real data in real situations, but for national applicability we generalized the process to allow for substitution of local programs.

Each planning stage – long-term, annual, and activity/incident – involves a different suite of questions, and therefore, different data and analysis tools. For long-range planning purposes, most questions concern the consequences of various fire management strategies on the ability to meet identified targets (for instance, full suppression versus wildland fire use). In general, this requires use of a landscape dynamic simulation model linked to fire behavior and fire effects. For fuels management planning, the primary question is one of prioritizing fuels treatments in the near-term (e.g., one to several years). For fire management planning, the primary questions relate to the presence of risks or benefits and the location and conditions producing these effects. For fire and fuels planning the focus is less on future vegetation and fuels conditions and more on the direct and indirect consequences of fire on existing vegetation and fuels. For these questions, a stand-based, deterministic model mapped at the landscape is often sufficient.

The following discussions and illustrations use FireFamilyPlus (Bradshaw and McCormick 2000, www.fire.org) with FlamMap (www.fire.org Finney in press) for fuels and fire planning and SIMPPLLE (SIMulating Pattern and Process at Landscape scales, Chew 1995, Chew et al. 2004) for long-range planning. These programs can be replaced by similar tools as is desirable or necessary. Knowledge gained during this phase was used to develop a detailed user's guide (Black et al. in prep.).

Generating information for fuels and fire planning

Figure 6. Flowchart for developing the Bitterroot National Forest 's map libraries.



The Bitterroot National Forest. The Bitterroot National Forest's Fire Ecologist used FEPF to develop map libraries to support revision of their Fire Management Plan and their fire stewardship program (prescribed fire, Wildland Fire Use and suppression) (**Figure 6**). Using guidelines from the existing Fire Management Plan, they selected weather conditions associated with the 80th, 90th, and 99th percentile Energy Release Component (ERC) as the critical fire weather thresholds to model. For the initial map library, they selected whitebark pine (*Pinus albicaulis*) and Canada Lynx (*Lynx canadensis*) as key management indicators. Because of the configuration of the forest (locally described as a 'bathtub ring' around the growing Bitterroot Valley of western Montana), dominant wind direction, and the species of interest, they selected

Crown Fire Potential as the key fire behavior parameter. The analysis area included the entire valley regardless of ownership. The watershed boundary (4th Code HUC) was used to define this area.

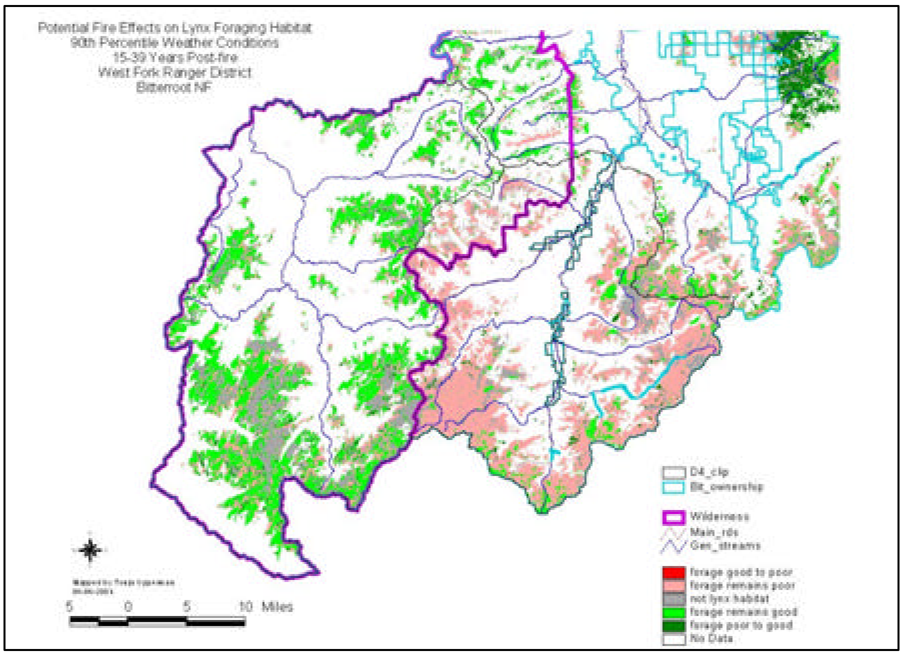
FireFamilyPlus (Bradshaw and McCormick 2000) was used to analyze historic weather conditions. Based on conversations with internal fire experts, they concluded that the valley should be modeled using several different weather stations, separately, as opposed to combining weather stations for the entire valley or using a single station for the entire area. A combination of Forest District and subwatershed boundaries was used to define five modeling sub-units. Since ERC does not use fine fuel moisture (1 and 10 hour fuels) or wind speed as part of its calculation, percentile values for each of these were determined individually. Thus, the 90th percentile condition for 1 hour fuel moisture was the value at which only 10% of observations were more extreme (drier). Appropriate wind speed values for modeling purposes were difficult to obtain from the weather station data, as hourly winds do not effectively capture maximum gusts. After consultation with local fire behavior and fire modeling experts, 90th percentile winds were multiplied by 1.5 and 99th percentile winds by 2 to better represent winds while retaining differences among sub-units. All values were captured on a weather form and used to develop the wind, weather, and fuel moisture input files necessary to run FlamMap. A FlamMap landscape file was created from gridded 2003 fuels data and topographic data obtained from the Fire Sciences Laboratory (RMRS, Missoula, MT).

Individual FlamMap runs were made for each threshold weather condition. Winds were run as uphill and set to the appropriate percentile value. Live fuel moistures were also changed from the default of 100% after consultation with Forest staff. Crown Fire Potential output was imported into a grid format.

Concurrently, forest staff consulted with appropriate research and forest biologists to develop crosswalks between crown fire potential (surface fire, torching, and active crown fire) and first order vegetative effects (low and mixed severity fire, stand replacing fire). These were based on known species tolerances to fire. (Forest vegetation simulators such as FFE-FVS (Reinhart and Crookston 2003) or SIMPPLLE can be used to validate such a crosswalk.) Secondary fire effects crosswalks were also created, linking the first order effects on vegetative conditions to effects on the target species. A third set of rules linked these species effects to management targets.

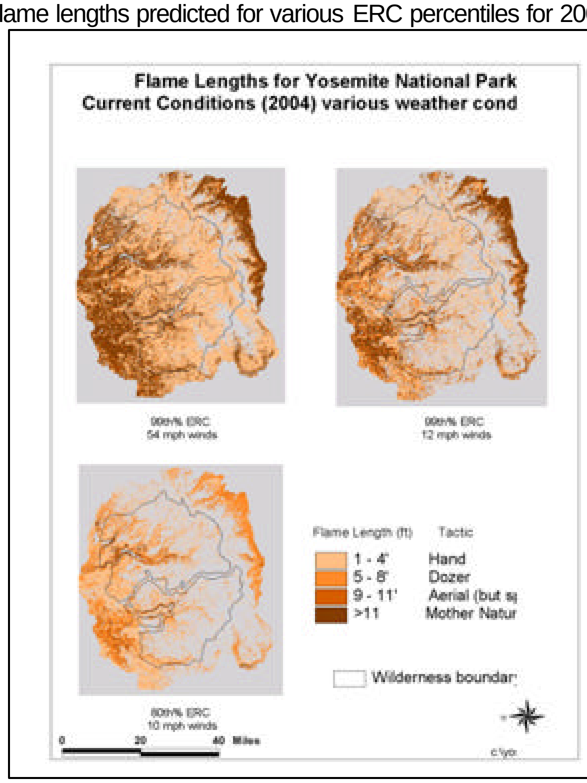
Application of these crosswalks to the fire effects data created the fire effects map libraries (**Figure 7**). These are posted on the Forest's central data server. Hard copy maps and an explanation of the datasets and their potential uses have been placed in binders and made available to each District's staff (line officers, resource and fire staff). Forest and project staff will monitor use of the datasets during the 2004 fire season and make adjustments to the datasets and process for 2005. Data will also be used during Fire Management Plan revision.

Figure 7. Example hard-copy map showing effects of fire under 90th% weather conditions on lynx habitat on the Westfork Ranger District, Bitterroot National Forest.



Yosemite National Park. We used FEPF to discover how fire – both suppression and WFU – over the past six years (1997-2003) has influenced firefighter safety in Yosemite National Park. Flame length is used in the Park's Fire Management Plan to determine how close firefighters can work to a fire as well as an indicator of potential fire effects and was chosen as the indicator of firefighter safety (**Figure 8**). As in the Bitterroot National Forest, Yosemite's Fire Management Plan identifies 80, 90 and 99th percentile ERC values as decision threshold conditions. We adjusted default live fuel moisture values for FlamMap runs. Unlike the Bitterroot National Forest, however, Yosemite staff determined that fire weather for the entire Park could be adequately captured using a single weather station. We ran FlamMap using the same wind, weather, and fuel inputs (fuel moisture files and conditioning periods) on the Park's 1997 and a 2003 fuels map, then compared the differences in flame length to quantify fire impacts on firefighter safety and progress towards resource targets.

Figure 8. Flame lengths predicted for various ERC percentiles for 2004.



The results of our comparative analysis are informative, though not as initially expected. The results indicate little change in fire fighter safety. There are several reasons for this.

- There was very little acreage of high severity fires captured in GIS data between 1997 and 2003. Thus, when the NPS and USGS scientists modeled changes in fuels and fuel models, they noted little change.
- Flame Length is modeled from Anderson Fire Behavior Fuel Models, which are not very sensitive to the changes that can occur from low to moderate severity fires.
- Changes in the fuel profiles that can be expected may not translate into changes in Flame Length. For instance, an increase in crown base height will reduce the potential for crown fire and reduce firefighter risk, but this change will only be captured by a Crown Fire Potential fire behavior output, not by Flame Length calculations.
- Because these areas are essentially 'healthy' – i.e., in a 'maintenance' fire regime, as opposed to 'restoration' regime, - fuel buildup between fires is minimal. Therefore, while the fuels reduction accomplished is profound, it is not of a large enough magnitude to be captured by current methodology.
- Finally, fuels reductions have a fairly short life, having greatest effect within the first 4 years post-fire, some influence to 8 years, and none beyond that. Changes in fuels and fuel models will be greatest immediately after a fire.

This exercise used the Park's first attempt to model new fuel models post-fire. Our results will be useful feedback to Park staff.

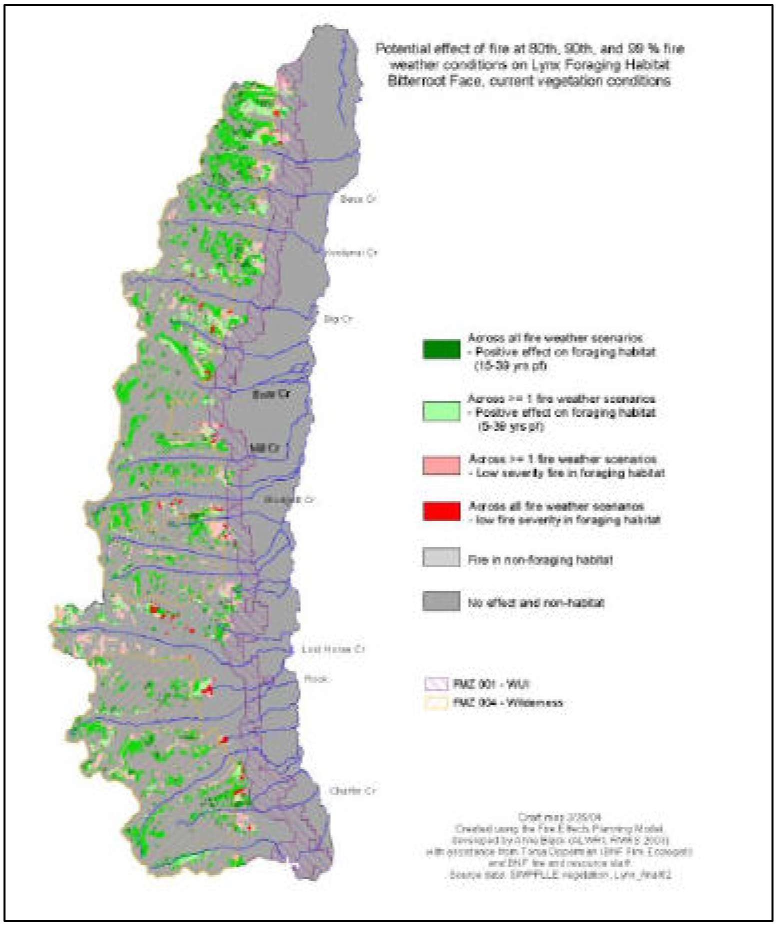
Generating information for long-range management planning

We generated information for two planning exercises on the Bitterroot National Forest: 1) using the FlamMap runs to identify potential treatment units along the Bitterroot Front (**Figure 9**), and 2) using SIMPPLLE to investigate the consequences of alternative fuels management strategies across the Forest (**Figure 10**). The purpose of these simulations was to demonstrate the feasibility and potential utility of FEPF, not to provide actual data. These exercises were also used to develop the detailed instructions found in the User's Guidebook and in the various web-distributed fact sheets (www.leopold.wilderness.net/staff/projects/project_001.htm).

Identifying fuel treatment units.

We combined the fire effects grids (e.g., all percentile weather conditions) for Lynx habitat to develop a map indicating where fire under all weather conditions creates benefits, and where fire under all weather

Figure 9. Identifying priority stands for Lynx on the Bitterroot Face.



conditions creates risks. Areas of consistent benefit are candidates for fire use; areas of consistent risk are candidates for mechanical treatments prior to reintroduction of fire. Areas with variable effects can be further analyzed for either prescribed fire or mechanical treatments.

Comparing alternative treatment strategies. One Bitterroot National Forest management concern is to restore fire to fire-adapted cover types and so it is of particular importance to know which stands are at-risk from fire. We identified fire-adapted cover types as stands of fire tolerant species of Ponderosa pine (Pinus ponderosa), Douglas-fir (Pseudotsuga menziesii) and western larch (Larix occidentalis). We used both SIMPPLLE and FlamMap to identify stands 'at risk' these are stands with a high probability of crown fire even under moderate fire weather conditions.

Using SIMPPLLE to compare probable burn type

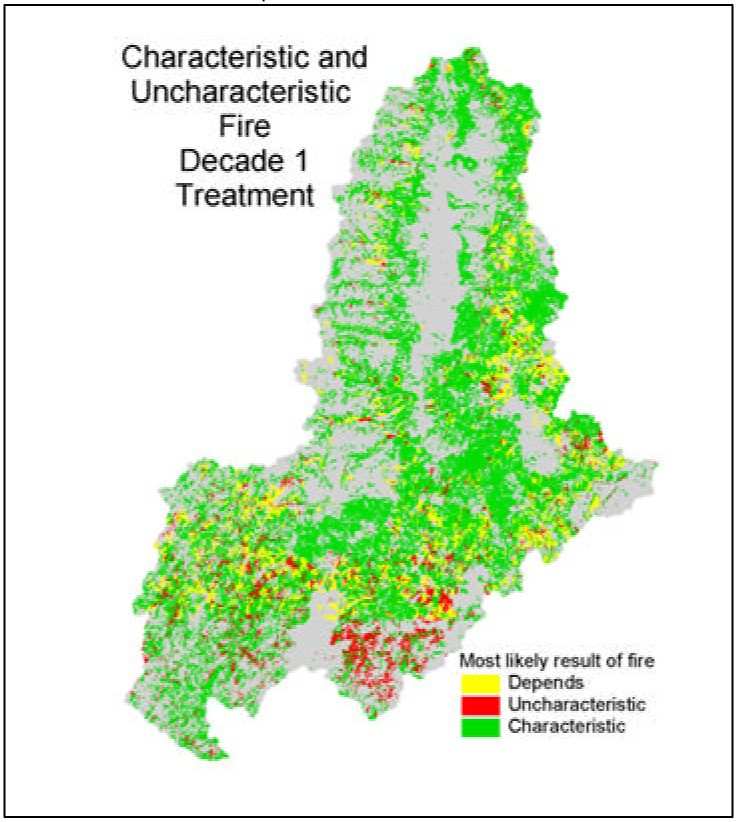
We programmed SIMPPLLE to treat the identified stands with a combination mechanical treatment followed by a broadcast underburn (ecosystem management thin and underburn). Treatments were intended to restore the stands to more historically natural conditions that support a surface fire, but not a crown fire.

We then ran a single decade SIMPPLLE simulation on the existing and the treated landscapes, using 30 iterations for each to capture ecosystem variability. For the existing condition, we ran two simulations, one using current fire management strategies (suppression and WFU zones), and one under a modified suppression strategy in which WFU was the dominant fire management strategy on all lands. We calculated the most probable fire type (light, mixed or stand-replacing fire) for each stand in each simulation from the SIMPPLLE output files. Most probable burn type maps were translated into fire effects maps using a rule-based crosswalk. These final effects maps identify risk and opportunity for meeting the fire restoration target. We were then able to quantify the difference between the alternatives and to identify how each would affect the Forest's ability to meet its stated target.

Using FlamMap to compare fire type

Alternatively, if one desires a quantitative measure of fire behavior, it is possibl e to use SIMPPLLE to generate the future landscape, apply a crosswalk from SIMPPLLE vegetation composition and structure to fuel model and canopy fuels for both the existing and future landscapes, then use FlamMap to predict fire behavior parameters for both situations. This combination can produce comparisons of fire behavior parameters, such as flame length or rate of spread, as well as fire type (surface, passive crown fire, active crown fire).

Figure 10. Fire benefit and risk, post treatment.

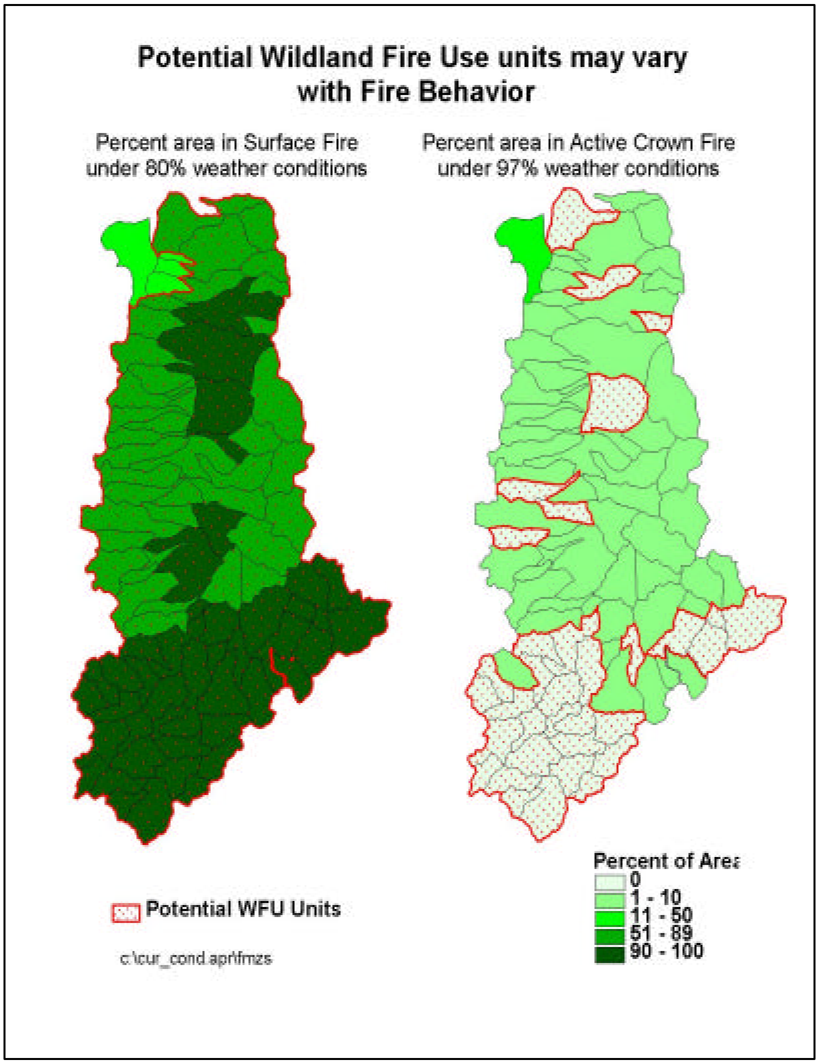


Developing information for Fire Management Planning

FEPF can facilitate fire management by helping to establish the range of acceptable appropriate management responses codified in the Land/Resource Management Plan. Either SIMPPLLE or FlamMap can be used for this purpose. In one exercise, we identified potential WFU zones by calculating the percentage of each subwatershed (6^{th} HUC) in a) low severity fire under moderate fire weather conditions and b) active crown fire under severe fire weather conditions from FlamMap output for the entire Bitterroot Valley (**Figure 11**). Subwatersheds with a high percentage of lands in a) and low percentage in b) were classed as candidates for Wildfire Use zones. Areas with high proportions of negative effects were classed as candidates for mechanical treatment and/or suppression. Areas falling in the middle can either be conditional WFU zones and/or used to define appropriate conditions for prescribed burns. In addition, Burn Pro can be used to assess the probability of burning by natural and/or human ignitions. When these probabilities are overlayed with flame length, fire effects, or the crosswalked effects on social targets, specific areas for fuels management can be prioritized.

Deleted: ¶

Figure 11. FEPF analysis to identify potential WFU zones.



Chapter 4

Technology Transfer

Report on Activities

We designed this project to address a perceived gap in the planning process. We did so by working closely with managers at all stages and keeping the management context firmly in mind. Activities followed the stages of technology transfer and the remainder of this final report is organized accordingly.

Technology transfer may be described as occurring in 4 different stages. In roughly chronological order, these are: *dialog*, *implementation*, *integration* and *institutionalization/utilization* (see notes from the JFSP Boise Technology Transfer meeting, May 24-26, 2004). The participants and the nature of activity change throughout this continuum, from innovative managers and researchers discussing the need for and outlining a research project during the *dialog* stage, to a slightly broader group of managers working closely with the researchers during *implementation* of the research project, to researchers, technology transfer specialists and a much broader group of managers holding discussions during *integration* when the initial products are first being disseminated for beta-testing, and finally to the full spectrum of managers and technology transfer specialists with little if any support from the primary researchers during the *institutionalization/utilization* phase.

We initially proposed to focus technology transfer activities during the *dialog*, and *implementation* stages. As the project developed however, we were able to make significant progress on the *integration* and *institutionalization/utilization* phases as well.

Dialog and Implementation

While really two separate stages, we lump dialog and implementation together for this report. The project was initially conceived through discussions with agency fire management officers and fuels specialists. We refined our understanding of the primary tools and information available and considered important for fire planning through a workshop and questionnaire of fire and fuels managers (Miller and Landres 2004). Specification of a conceptual model and initial construction of FEPF, including identification of specific tools and how they interact, were presented at meetings with managers and researchers. Development and testing of FEPF was conducted using data for both the Beaverhead-Deerlodge and Bitterroot National Forests. During this phase we developed fire behavior and fire effects maps using both the static, stand-based pathway (FlamMap) and the dynamic, landscape-based pathway (SIMPPLLE) for two sites: 1) the Bitterroot Face, Stevensville Ranger District and Bitterroot National Forests; and 2) the Gravelly Range, which includes wilderness, roadless and multiple use lands administered by the Red Rocks National Wildlife Refuge, Dillon Resource Area, and Beaverhead-Deerlodge National Forest. Output from this process was illustrative in nature and served as a proof of concept.

A summary of *additional* communication activities and products follows.
Meetings with managers: (Total contacts: ~ 100)
Planning Teams: Beaverhead-Deerlodge National Forest (USFS, 2002); Larimer Foothills Fire Learning Network (TNC, county, state, USFS, BLM, 2002); National Fire Plan Endangered Species Assessment (BLM, USFS, NOAA, USFWS, 2003)
Fire Staff: Region 1 Fire Management Officer's winter meeting (USFS, 2003); Bitterroot National Forest FMO's workshop (USFS, 2002); Custer National Forest, Beartooth Ranger District fire staff (USFS, 2003); Yosemite National Park (NPS, 2003)
Other notable one-on-one contacts: Yakama Tribe (2002); Saguaro National Park (NPS, 2003); Ken Kerr [[use his title instead of his name?]](USFWS, 2002); Colorado Springs City Fire Management (City, 2003)

Management-oriented conventions/symposia: (Total contacts: ~200)
Poster presentation at the Association of Fire Ecologists (2002)

Research-oriented conventions/symposia: (Total contacts: ~ 300)
Oral presentations to: Missoula Fire Lab seminar (2003); Joint Fire Science Program's PI-workshop (2003)

Integration

Integration activities may also be thought of as a 'beta-test' phase in which promising initial research results are presented to a broader community. The purpose of this stage is to further refine the research results and to begin developing a plan for appropriate packaging, targeting and dissemination. Communication reaches out to a broader group of managers and researchers than those initially involved during the dialog and implementation stages.

We identified a number of management situations in which FEPF could be used to develop information for specific planning activities. We participated in a number of planning efforts (Forest Plan and Resource Area Plan revision for the Beaverhead-Deerlodge N.F. and Dillon R.A.; Western Montana Planning Zone; Butte Municipal Watershed Fuels Treatment Project; Custer National Forest's Pryor Mountains Fire Management Plan; Bitterroot Ecosystem Management Research Project). For these efforts, we still collated the input data and conducted the analysis, but worked more closely with management staff than in the previous phase. Results were presented to managers for their feedback.

While our vision was to use FEPF as a tool to *develop* alternatives, forest planners view the tool most useful for *effects analysis*. Unfortunately, as of June, 2004, none of these planning processes are at the effects analysis stage. All remain interested in using FEPF at the effects analysis stage, however, which will occur over the next 2-3 years. In the case of the Butte Municipal Watershed project, there were no ecological targets of management interest within the project boundaries; thus while we were able to introduce managers to FEPF, gain additional insight into how managers would use the model and thus refine the model, we were unable to provide specific information for their planning efforts.

To take the next step of integration, we sponsored development of map libraries by managers themselves. This stage sought to obtain field review of our initial analyses, train field staff in FEPF, and obtain input from users/managers on necessary refinements of both the process and communication devices (fact sheets, website, and guidebook). We contracted with the Fire Ecologist on the Bitterroot National Forest (BNF) to develop a full suite of maps for the forest and, in the process, to help revise the Guidebook from the valuable perspective of an end user. As of the end of the project, the BNF has a map library of fire behavior for three critical weather thresholds and fire effects for two key management targets Canada Lynx (*Lynx canadensis*) and whitebark pine (*Pinus albicaulis*). This information is being made available in digital form to all Districts and an information sheet is being included in the Fire Packet for 2004. Data and analysis are going to be used for 2005 revision of the Fire Management Plan.

We have also developed a fire behavior map library for the Sapphire Mountain Range, a large area of wilderness and roadless area including the Anaconda-Pintlar Wilderness (jointly managed by the Beaverhead-Deerlodge and Bitterroot National Forests) and the Welcome Creek Wilderness (managed by the Lolo National Forest). This information has been made available to the appropriate Forest staff.

A key aspect of our communication plan during this phase was the development of a website that serves immediately useful information to managers. Although the project was still a work in progress, we were ready to present the concept and describe the FEPF process. As such, the website was dynamic and continually being updated as the project progressed. In addition to posting materials presented at various conferences and meetings, we developed a series of nine 2-3 page fact sheets addressing key questions managers are likely to have about the framework and process. These include (see appendix):

- What information do I need in order to use this process?
- What types of information does this process generate?
- How can this information be used?
- How can I quantify benefits from fire?
- How can I identify opportunities to burn?
- Can I use this process to prioritize treatments?
- How can this process assist in developing WFIP's and WFSA's?
- How can I identify areas of potential ecological damage?
- How do I aggregate or balance conflicting management goals?

A summary of key contacts and communication during this stage follows.
Meetings with managers: (Total contacts: ~75)

Planning Teams: Beaverhead-Deerlodge National Forest (USFS, 2003); Western Montana Planning Zone- Fire subteam (USFS, 2003); Butte Municipal Watershed Project (USFS, 2003); Region 1 Resource Inventory and Monitoring Board (USFS, 2003); Bitterroot Ecosystem Management Research Project (USFS, 2003-2004);
Fire Staff: Bitterroot National Forest (USFS, 2003-2004); Custer National Forest, Beartooth Ranger District fire staff (USFS, 2003-2004); Yosemite National Park (NPS, 2003-2004)
Other fora: Missoula Wilderness Forum (University of Montana, CESU, USFS, public, 2003)

<u>Management-oriented conventions/symposia:</u> (Total contacts: ~ 500)
Association of Fire Ecologists (2003); Wildland Fire Impacts on Watersheds and Fire (2003); National Fire Plan/JFSP Oregon Large Fire ??? (2003) ; Risk Assessment for Decision-making Related to Uncharacteristic Wildfire Conference (2003); National Fire Plan Conference (2004)

<u>Research-oriented conventions/symposia:</u> (Total contacts:~ 30)
Oral presentation to Boise Aquatics Lab (RMRS, 2004)

Institutionalization

Institutionalization moves research ideas and products into the structure of an agency and its business model. Activities may include further development and refinement of the product, development and implementation of a dissemination plan to inform the broader community about the product, and development of training programs and materials.

During 2004 we devoted considerable energy to identify appropriate venues for institutionalization of FEPF and its concepts. Specific activities included:

- Submission of proposal to RSAC/GSTC for further development (2004). Entitled " Developing near real-time predictions of potential fire benefits and risks for incident management", we proposed that RSAC develop and integrate FEPF into a GIS system that automatically produces maps of 'risks' and 'benefits' based on predicted fire behavior and perimeters output by

Farsite. This information would then be available to the incident command and resource staff along with expected fire behavior. This was not selected for RSAC/GSTC's FY05 workplan, but we were asked to resubmit in 2005 as there was considerable interest in the idea.

- Participation in the JFSP's Technology Transfer workshop (2004)
- Coordination with the Arthur Carhart National Wilderness Training Center to integrate FEPF into their wilderness training courses (2004 and ongoing).
- Selection for National Highlight in National Fire Plan 2003 Annual Report.
- Discussions with ESRI regarding incorporation of FEPF into a new Arc Extension for fire planning (2004 and ongoing).
- Discussions with the Fire Program Analysis Team (NIFC) regarding incorporation of benefits/risk calculations in the new Fire Program Analysis tools (2003 and ongoing).
- Publication of a suite of written materials on the project aimed at managers and users of FEPF: a Guidebook to FEPF, short fact sheets, posters, handouts, and a web site.
- Continued support for management units interested in working with the model including Beaverhead-Deerlodge National Forest, Custer National Forest, Sierra National Forest.

<u>Meetings with managers</u> (Total contacts: ~ 100)

Planning Teams: Fire Planning Assessment Team (NIFC, 2004); ESRI- Front Range Fuels Treatment Project (2004); Beaverhead-Deerlodge National Forest (2002-2004); Bitterroot Ecosystem Management Research Project (USFS, 2004);

Fire Staff: Greater Yellowstone Area's spring fire meeting (USFS, NPS, 2004); Selway-Bitterroot Wilderness fire spring meeting (USFS, 2004); Sierra National Forest (USFS, 2004)

Management Workshops: Wilderness Cooperative Ecosystem Unit (CESU - NPS, State, USFS, USFWS, BIA, 2004)

Other fora: Missoula Wilderness Forum (University of Montana, CESU, USFS, public, 2004); Arthur Carhart National Wilderness Training Center (2004)

<u>Management-oriented conventions/symposia:</u> (Total attendance: ~600)

Attend: Association of Fire Ecologists (2004); National Fire Plan (annual meeting 2004)

Research-oriented conventions/symposia: (Total attendance: ~ 250)

Boise Aquatics Lab (RMRS, 2004) Joint Fire Science Program's PI-workshop (attend 2004)

Chapter 5

Conclusions

We developed the Fire Effects Planning Framework alongside managers as much as possible during real planning efforts. This allowed us to develop an appreciation for the effort and complexity involved. Although FEPF was designed to create products that contribute significantly to the various planning processes while minimizing additional work by field staff, and this does not mean that there is no work involved! FEFP is a structure, not a stand-alone tool run through a GUI interface. The tools and techniques incorporated into FEPF require local input and expertise.

While fire, fuels and habitat data and knowledge increase daily, our understanding is still limited and models are still simplifications of reality. The 'best available science' will often be a combination of empirical and process-based models supplemented by local expertise. The more closely the fire and resource staff work – to identify datasets, targets and measures - the greater their confidence will be in the outcomes and the greater their understanding of the biases and limitations inherent in the data. For instance, we know that the existing 13 Anderson Fire Behavior Fuel Models do not capture the full spectrum of fuel configurations. This became readily apparent in our work with Yosemite National Park. Because few fires over the past 5 years burned significant acreages with high severity, Park staff made minimal changes to fuel models within the perimeter of the fires, even though substantial changes certainly occurred to the surface fuels and understory. Since flame length calculations are based on fuel models, little to no change in firefighter safety was detected between the two time periods. Likewise, since the canopy fuels and fuel models don't capture much of the understory structure, it is difficult to detect changes in crown fire potential in stands with 130' tall trees and initial canopy base heights of 45', even though fire is likely to have a significant impact on 10 - 20' tall understory vegetation. This experience will be useful for future fuel modeling exercises.

Working alongside managers also helped us understand the timing of analysis. Our initial vision was that FEPF would be used as a tool to *develop* alternatives. However, in every planning effort with NEPA analysis we were exposed to (project, landscape and regional scale), planners consistently referred to FEPF as a tool useful for *effects analysis*. Unfortunately, our portion of the project was complete before any of these efforts reached the effects analysis stage.

FEPF is functional and feasible for most management units. It uses widely available data, computer tools and local expertise. It does not require proprietary programs (other than a GIS system); all programs are available on-line (www.fire.org, www.frames.org). New tools and information can be incorporated immediately upon release. Ultimately, adoption of FEPF for use in planning will be a function of outreach to managers, incorporation into fire training, and interagency fire planning. We are currently working on all of these fronts.

References

Andrews, P.L. 1986. BEHAVE: fire behavior prediction and fuel modeling system. USDA Forest Service GTR-INT-194.

Barrett, T. M. 2001. Models of vegetation change for landscape planning: a comparison of FETM, LANDSUM, SIMPPLLE, and VDDT RMRS-GTR-76-WWW/ GTR-RMRS-076. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 14 p.

Bunnell, D.L. and G.T. Zimmerman. 1998. Fire management in the north fork of the Flathead River, Montana: an example of a fully integrated interagency fire management program. Pp 274-279 in T.L. Pruden and L.A. Brennan (eds.). Fire in ecosystem management: shifting the paradigm from suppression to prescriptions. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Talahassee, FL.

Burgan, R.E., P.L. Andrews, L.S. Bradshaw, C.H. Chase, R.A. Hartford and D.J. Latham. 1997. Current status of the Wildland Fire Assessment System (WFAS). Fire Management Notes 57:14-17.

Burton, T.A., D.M. Dether, J.R. Erickson, J.P. Frost, L.Z. Morelan, W.R. Rush, J.L. Thornton, C.A. Weiland and L.F. Neuenschwander.1998. Resources at risk: the Boise NF fire-based harzard/risk assessment for the Boise National Forest. PP 337-341 in T.T. Pruden and L.A. Brennan (eds.). Fire in ecosystem management: shifting the paradigm from suppression to prescriptions. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Talahassee, FL.

Bradshaw, L. and E. McCormick. 2000. FireFamily Plus user's guide, version 2.0. USDA Forest Service RMRS-GTR-67WWW. Ogden, UT.

Chew, J.D. 1995. Development of a system for simulating vegetative patterns and processes at landscape scales. PhD Dissertation. University of Montana, Missoula.

Chew, J.D., C. Stalling and K. Moeller. 2004. Integrating Knowledge for Simulating Vegetation Change at Landscape Scales. *Western Journal of Applied Forestry*.19 (Part 2):102-108.

Close, K.R. and R.H. Wakimoto. 1995. GIS applications in wildland/urban interface fire planning: the Missoula County (Montana) project. PP 180-185 in Proceedings: Symposium on Fire in Wilderness and Park Management. USDA Forest Service GTR-INT-320.

Davis, B. and C. Miller. 2004. Modeling wildfire probability using a GIS. In: Proceedings of the ASPRS 2004 Annual Conference, Denver, USA. May 23-28. American Society of Photogrammetry and Remote Sensing (CDROM).

ESRI [Environmental Systems Research Institute]. 1998. ARC/INFO. Version 7.2.1. ESRI, Redlands, CA.

Finney, M.A. 1994. Modeling the spread and behavior of prescribed natural fires. PP 138-143 in Proceedings of the 12th conference on fire and forest meteorology. Jekyll Is. GA, Oct 26-28, 1993.

FRAMES 2003. Fire Research and Management Exchange System, Fire Management Tools Online. [Online]. Available: http://www.frames.gov/tools/#RERAP [May 3, 2003]

Kearns, Stefanie A., and V. Wright. 2002. Barriers to the use of science: U.S. Forest Service case study on fire, weed, and recreation management in wilderness. Unpublished Report. Aldo Leopold Wilderness Research Institute, USDA Forest Service, Rocky Mountain Research Station, Missoula, MT. 70 p. On file at: Leopold Institute, P.O. Box 8089, Missoula, MT 59807.

Lasko, R.J. and P.R.Tine. 1995. Quantifying risk and displaying ecological consequences of prescribed fire decisions in the Boundary Waters Canoe Area Wilderness. PP 226 in Proceedings: Symposium on Fire in Wilderness and Park Management. USDA Forest Service GTR-INT-320.

Lee, B.; Meneghin, B.; Turner, M.; Hoekstra, T. 2003. An evaluation of landscape dynamic simulation models. Fort Collins, CO : USDA Forest Service, Inventory and Monitoring Institute [http://www.fs.fed.us/institute/news_info/evaluation_LDSM.pdf]

Main, W.A., D.M. Paananen, and R.E. Burgan. 1990. FIREFAMILY 1988. General Technical Report NC-138, U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station, St. Paul, MN.

Miller, C. 2003a. The spatial context of fire: a new approach for predicting fire occurrence. Pages 27-34 in K.E.M. Galley, R.C. Klinger, and N.G. Sugihara (eds.). Proceedings of Fire Conference 2000: The First National Congress on Fire Ecology, Prevention, and Management. Miscellaneous Publication No. 13, Tall Timbers Research Station, Tallahassee, FL.

Miller, C. 2003b. Wildland fire use: a wilderness perspective on fuel management. Pages 379-385 in P. Omi, and L. Joyce (coords.). Fire, Fuel Treatments, and Ecological Restoration: Conference Proceedings; 2002 16-18 April; Fort Collins, CO. Proceedings RMRS-P-29. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 475 p.

Miller, C. and P. Landres. 2004. Exploring information needs for wildland fire and fuels management. USDA Forest Service GTR-RMRS-127.

Miller, C., Landres P.B., and P. B. Alaback. 2000. Evaluating the risks and benefits of wildland fire at landscape scales. PP 78-87 In: Neuenschwander, L.F. and K.C. Ryan (tech. eds.) Joint Fire Science Conference and Workshop: proceedings; 1999 June 15-17, Boise ID. University of Idaho, Moscow, ID.

NIFC (National Interagency Fire Center). 1998. Wildland and Prescribed Fire Management Policy: implementation procedures reference guide. (G. T. Zimmerman and D. L. Bunnell, compilers). Accessed on-line 1/03.

Parsons, D. J. and P. B. Landres. 1998. Restoring natural fire to wilderness: how are we doing? Pp 366-373 in T.L. Pruden and L.A. Brennan (eds.). Fire in ecosystem management: shifting the paradigm from suppression to prescriptions. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Talahassee, FL.

Perkins, J.1994. Managing fuels for forest protection. Pp 61-68 in Proceedings of the 15th annual forest vegetation management conference. January 25-27, 1994. Redding, CA.

Reinhardt, E. D. and N. L. Crookston. 2003. The fire and fuels extension to the Forest Vegetation Simulator. USDA Forest Service RMRS-GTR-116.

Reinhardt, E., R. E. Keane and J.K. Brown. 1997. FOFEM's user's guide. USDA Forest Service GTR-INT-344.

Rowe, W.D. 1975. An 'anatomy' of risk. US Environmental Protection Agency. Washington, D.C.

Sapsis, D., B. Bahro, J. Spero, J. Gabriel, R. Jones, and G. Greenwood. 1996. An assessment of current risk, fuels, and potential fire behavior in the Sierra Nevada. Sierra Nevada Ecosystem Project, final report to Congress, status of the Sierra Nevada, volume III, assessments, commissioned reports, and background information. University of California – Davis, Center for Water and Wildland Resources.

Saveland, J. 1998. Prescribed fire: the fundamental solution. Pp 12-16 inT.L. Pruden and L.A. Brennan (eds.). Fire in ecosystem management: shifting the paradigm from suppression to prescriptions. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Talahassee, FL.

Schutt, Russell K. 1999. Investigating the Social World: the process and practice of research. 2nd Edition. Pine Forge Press, Sage Publications, Thousand Oaks, CA.

Suter, G.W. (editor). 1993. Ecological risk assessment. Lewis Publishers, Boca Raton, FL.

Urban, D.L., C. Miller, P.N. Halpin, and N.L. Stephenson. 2000. Forest gradient response in Sierran landscapes: the physical template. Landscape Ecology 15: 603-620.

USDA Forest Service. 2000. Interagency Initial Attack Assessment (IIAA) User's Guide version 1.2.0. Accessible by federal employees at: www.fs.fed.us/fire/planning/nist; Accessible to others through National Fire and Aviation Management Information Systems Team. 3833 S. Development Ave, Boise, ID.Wiitala, M.R. and D.W. Carlton. 1994. Assessing long-term fire movement risk in wilderness fire management. Pp 187-194 in Proceedings of the 12th international conference on fire and forest meteorology. October 26-218,1994. Jekyll Is. GA.

Wiitala, M.R. and D.W. Carlton. 1994. Assessing long-term fire movement risk in wilderness fire management. Pp 187-194 in Proceedings of the 12th international conference on fire and forest meteorology. October 26-218,1994. Jekyll Is. GA.

Appendices

Fact sheets posted on the Website

Map Library for the Bitterroot National Forest (West Fork RD)

Published publications